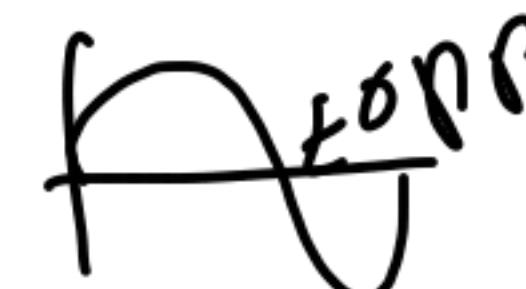


Resistance $\Rightarrow (R) \rightarrow$ opp. of flow of current $\rightarrow DC (\Omega)$

Reactance $(X) \rightarrow$ opp. of change of flow of current $\rightarrow AC (\Omega)$


X_L
(L)

X_C
(C)

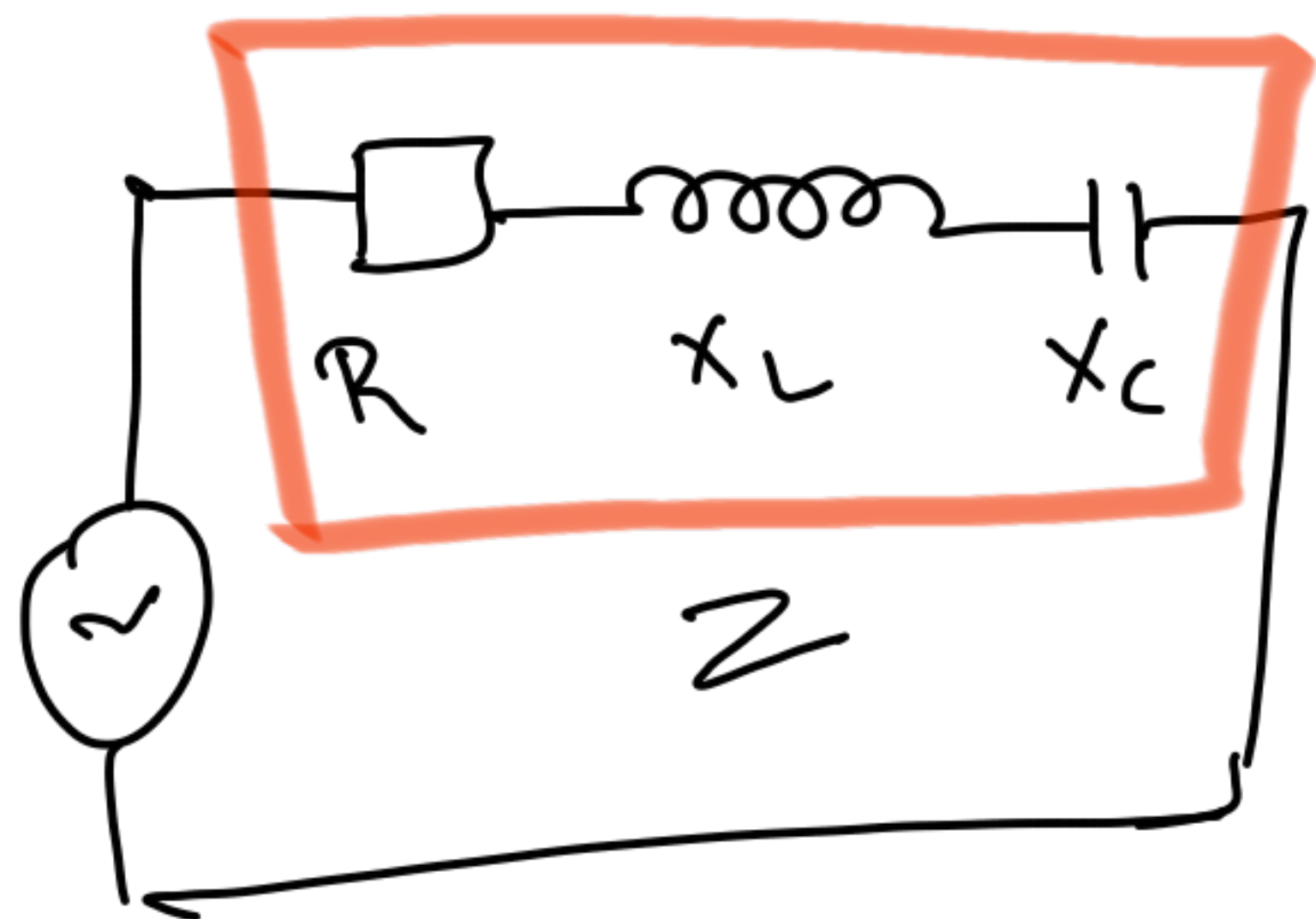
$$X_L = 2\pi fL \Rightarrow X_L \propto f$$

$$X_C = \frac{1}{2\pi fC} \Rightarrow X_C \propto \frac{1}{f}$$

$f \uparrow \Rightarrow X_C \downarrow$

Impedance $(Z) \rightarrow (\Omega)$

$\Rightarrow R \text{ } Z \text{ } X$



$$Z = \sqrt{R^2 + X^2}$$

$$X \approx X_L \sim X_C$$

Pure Resistor

$\rightarrow V \propto I$ (In phase)

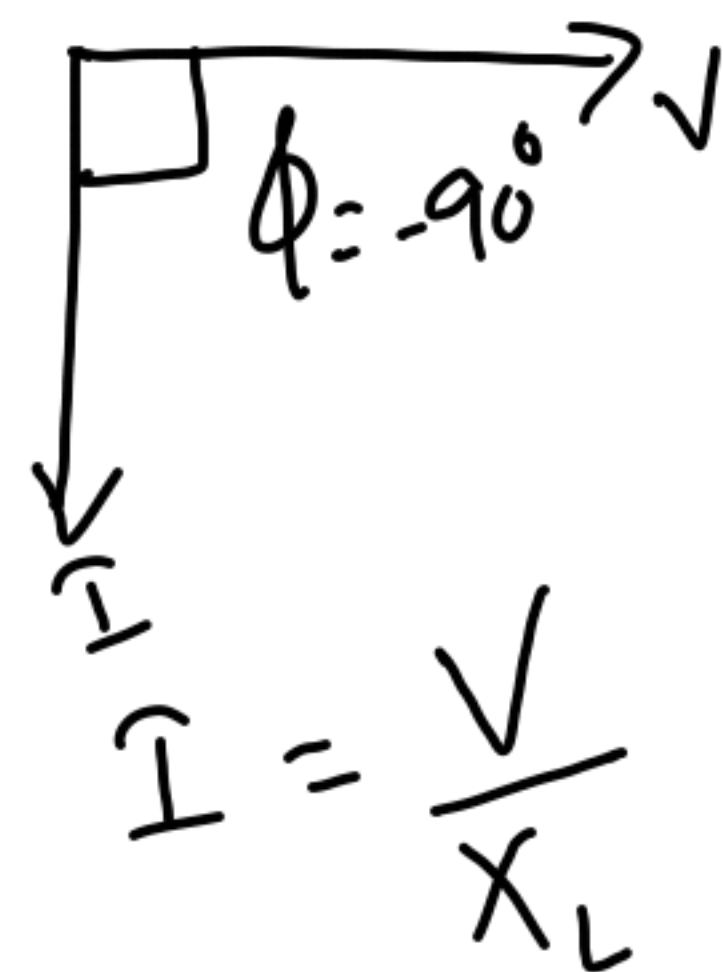


$$I = \frac{V}{R}$$

$$Z = R$$

Pure Inductor

$\rightarrow V \propto I$
(not in phase)

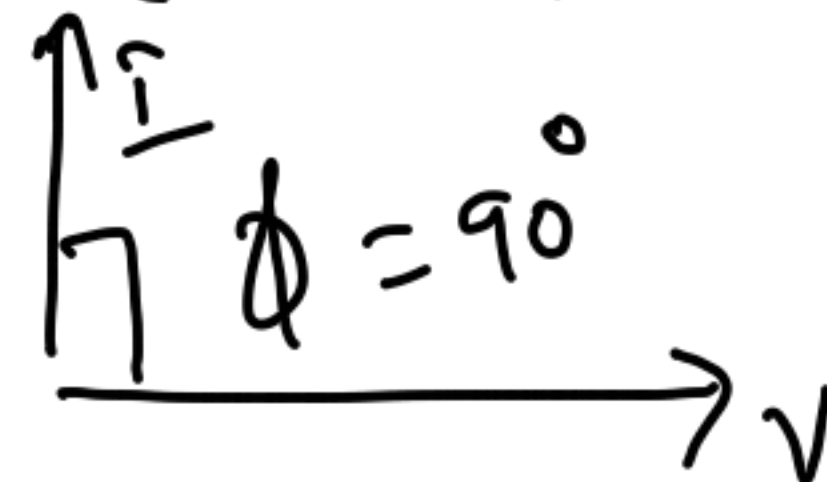


$$I = \frac{V}{X_L}$$

$$Z = X_L$$

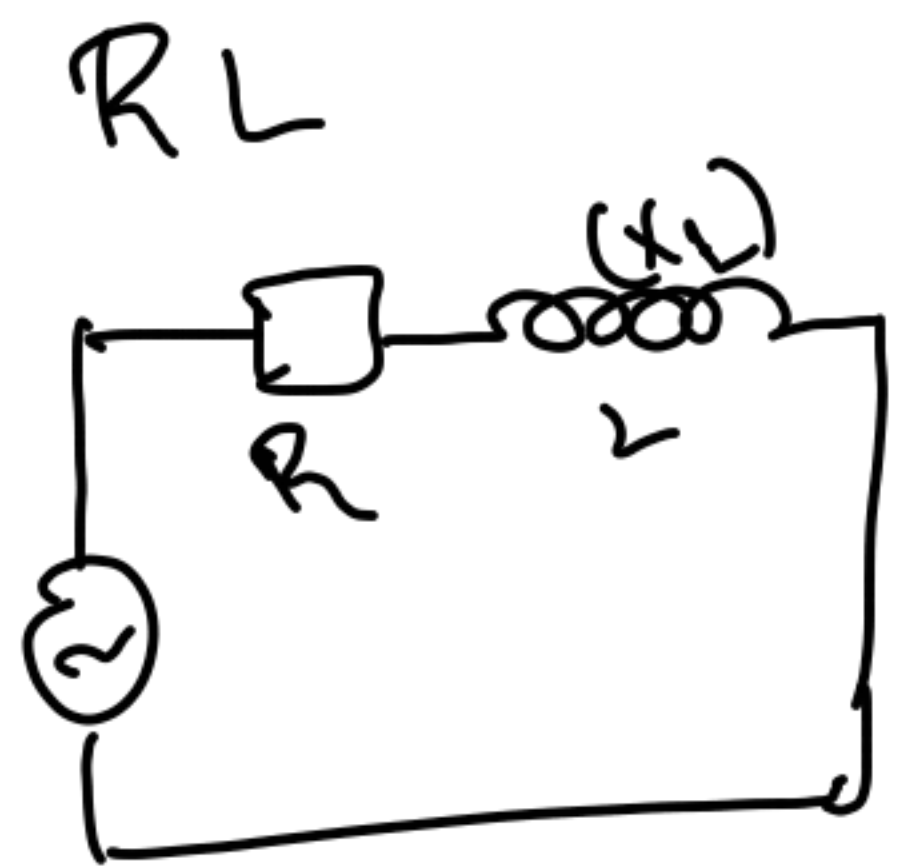
Pure Capacitor

$\rightarrow V \propto I$
(not in phase)



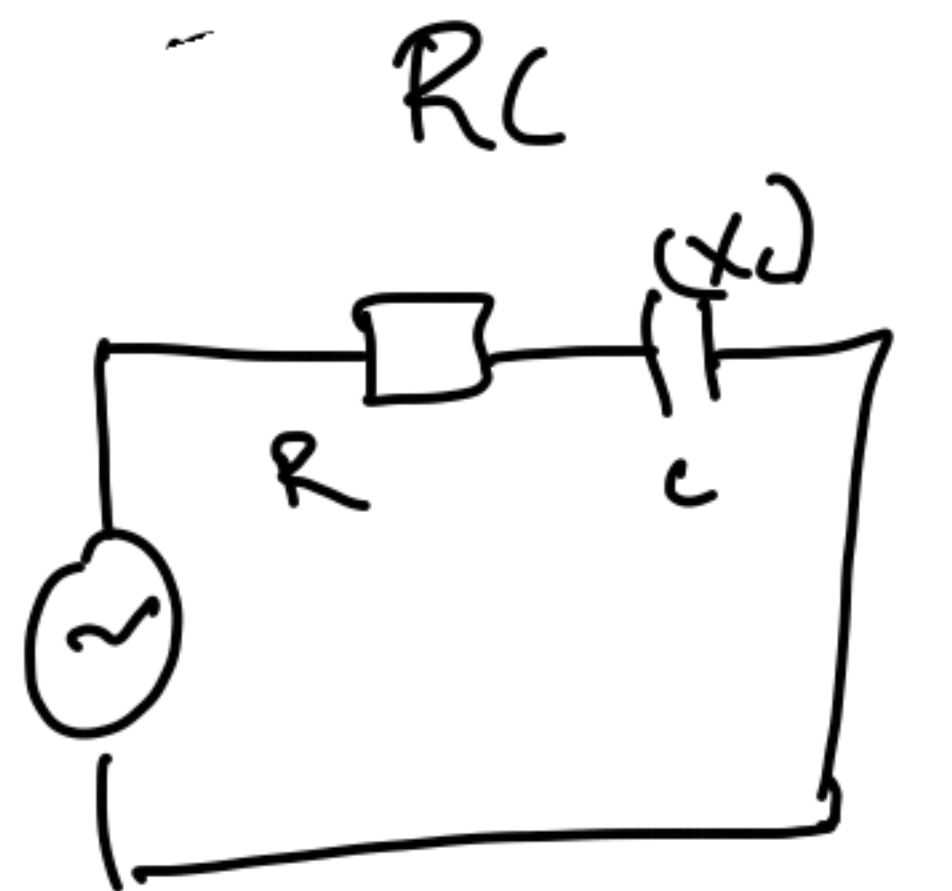
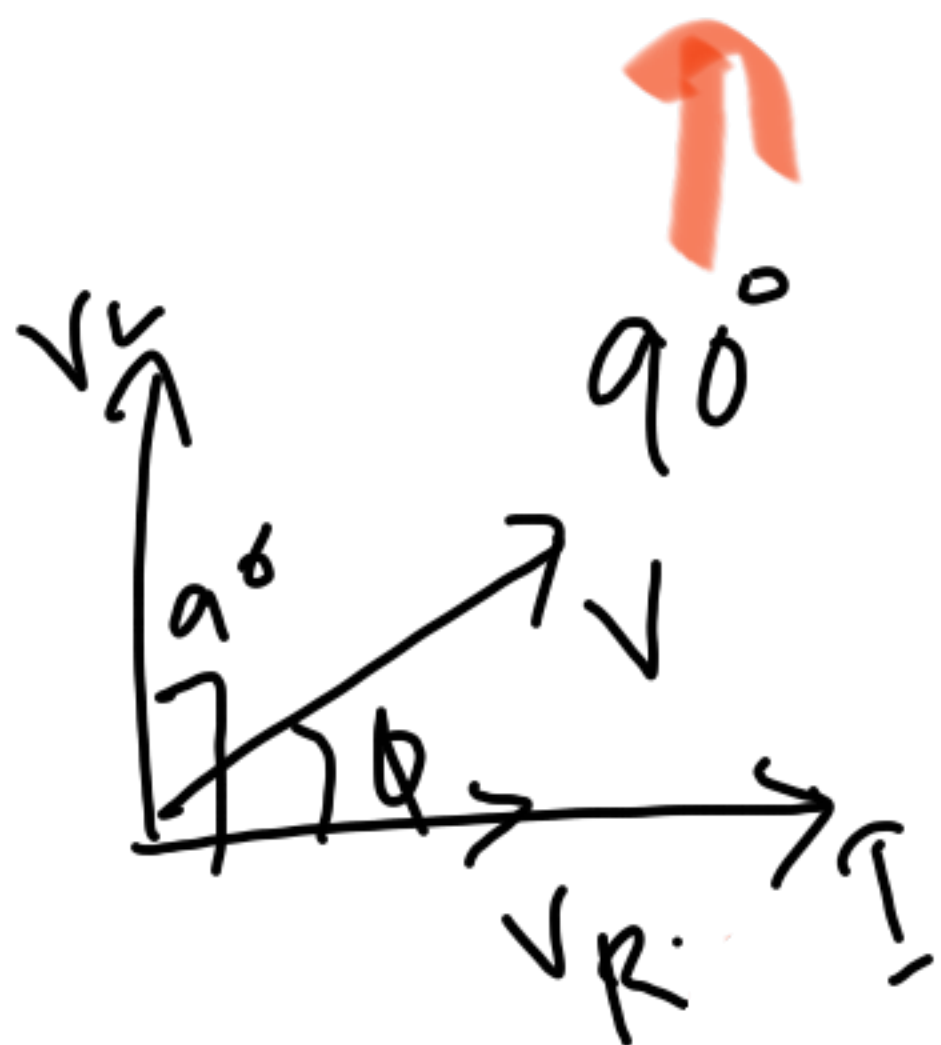
$$I = \frac{V}{X_C}$$

$$Z = X_C$$



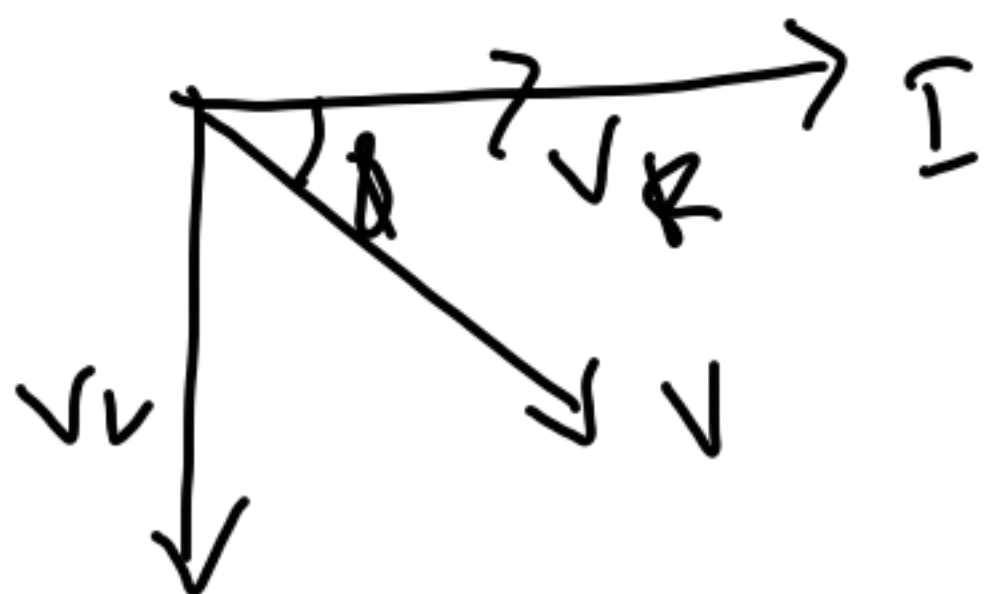
$$Z = \sqrt{R^2 + X_L^2}$$

$$Z = R + jX_L$$



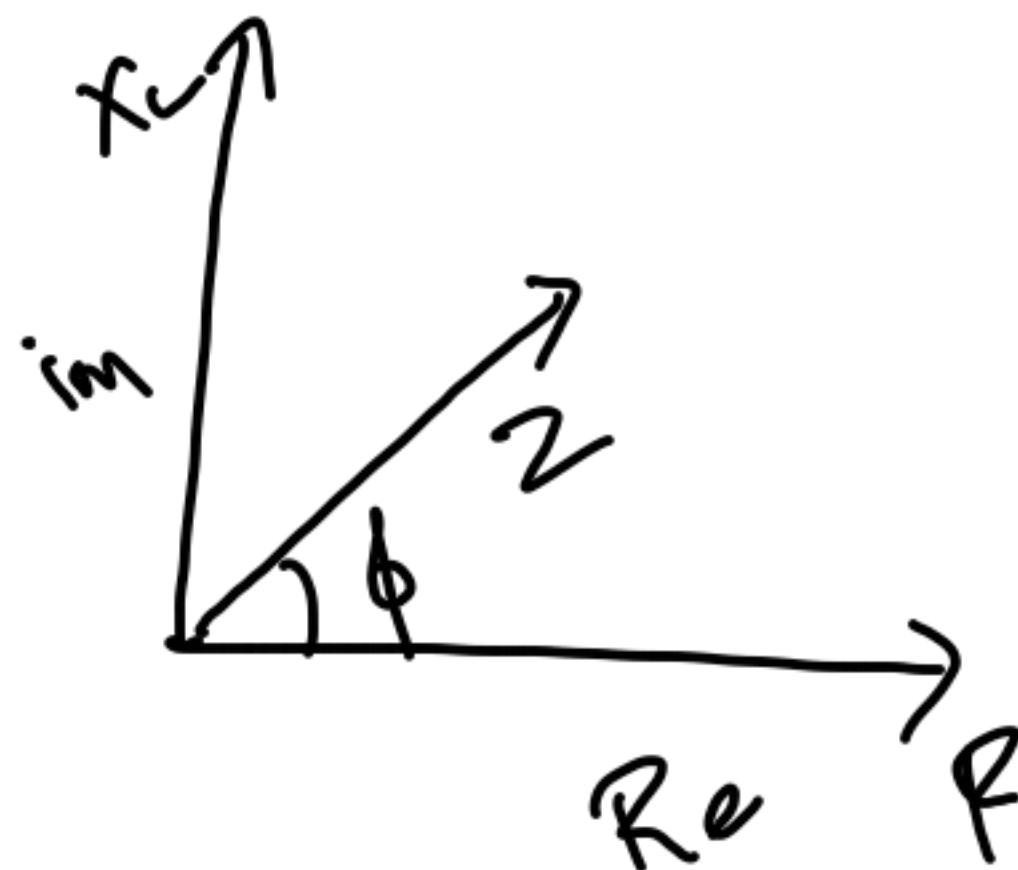
$$Z = \sqrt{R^2 + X_C^2}$$

$$Z = R - jX_C$$



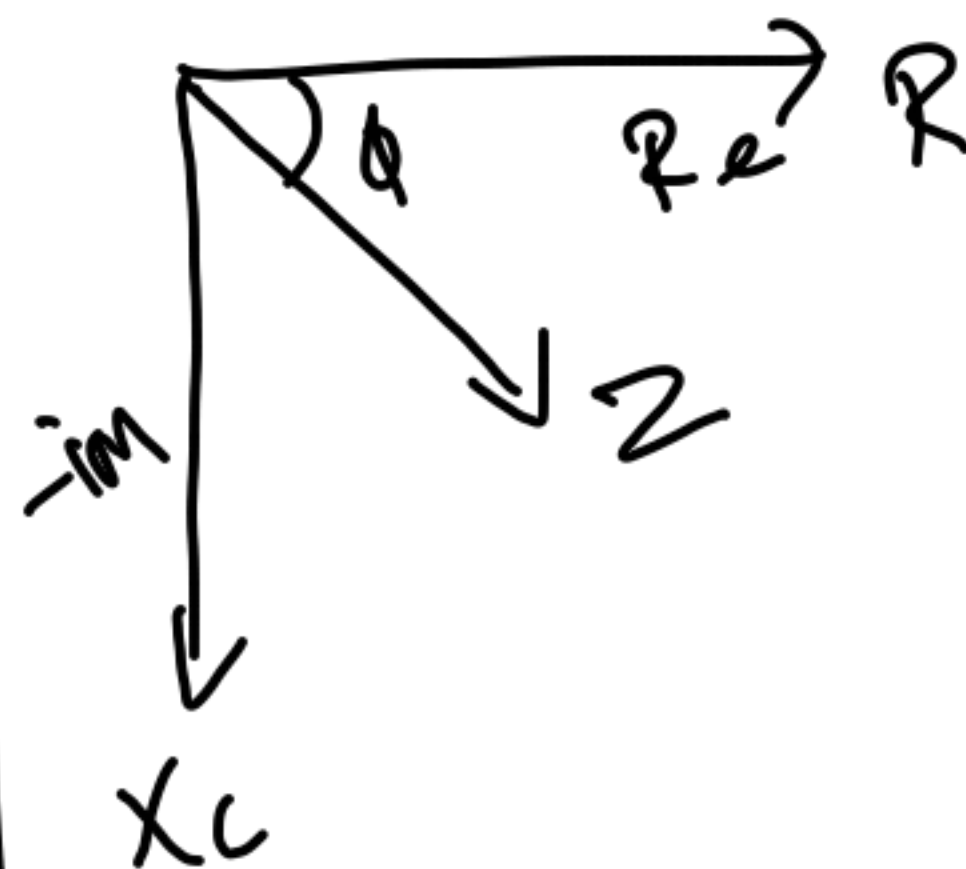
R_L

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$



R_C

$$\phi = \tan^{-1}\left(\frac{-X_C}{R}\right)$$

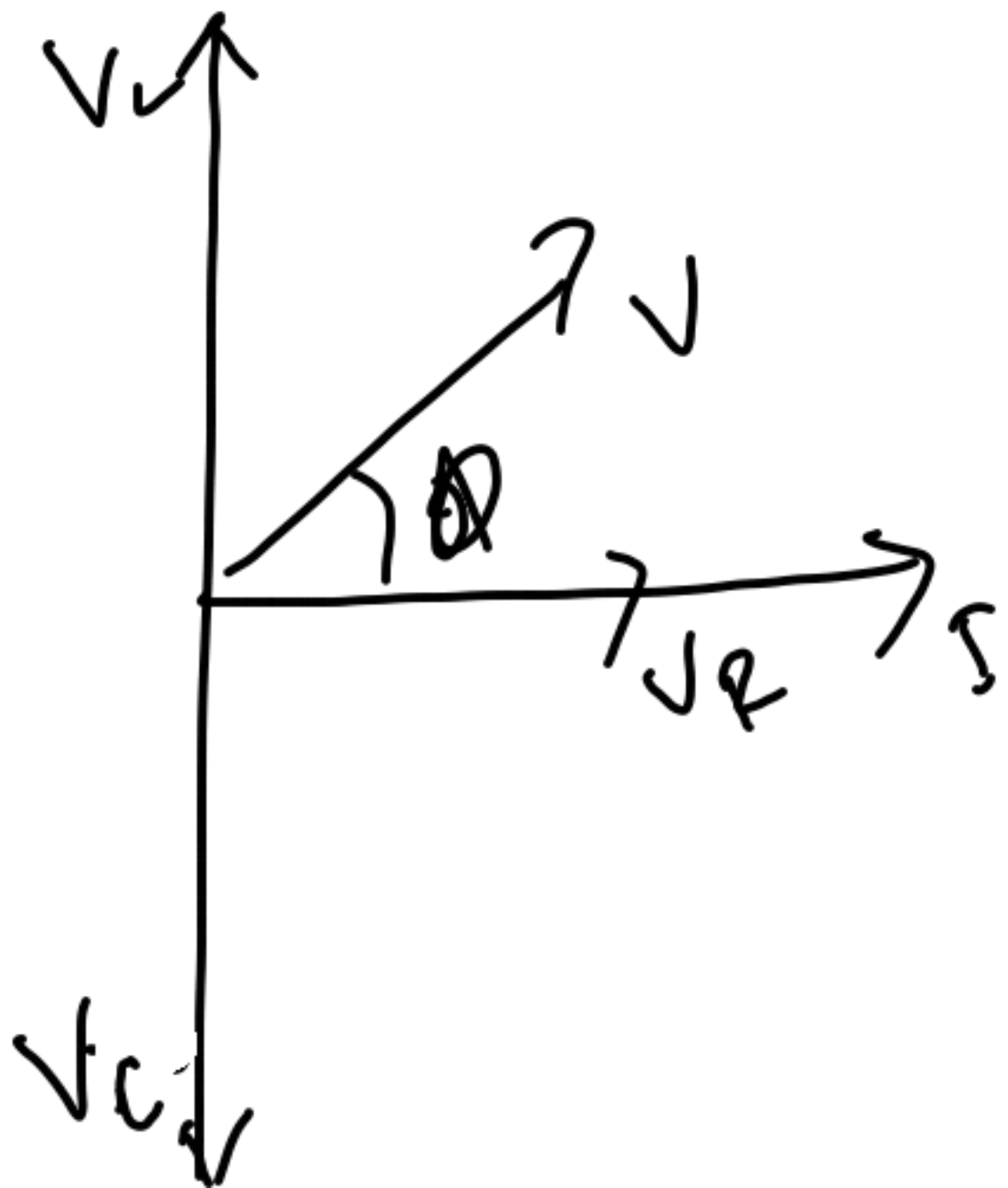


RLC.

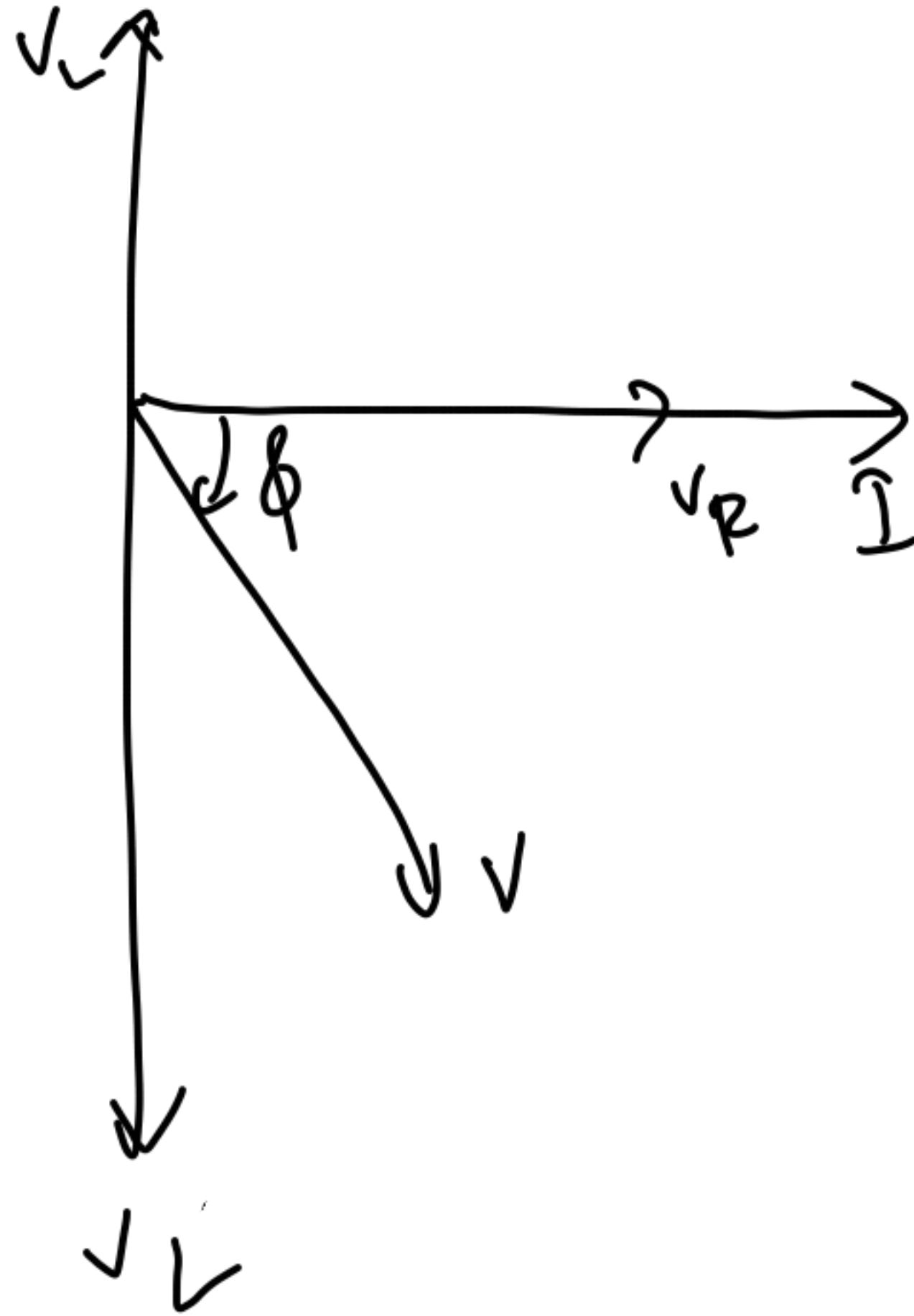
$X_L > X_C$ (RL)

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

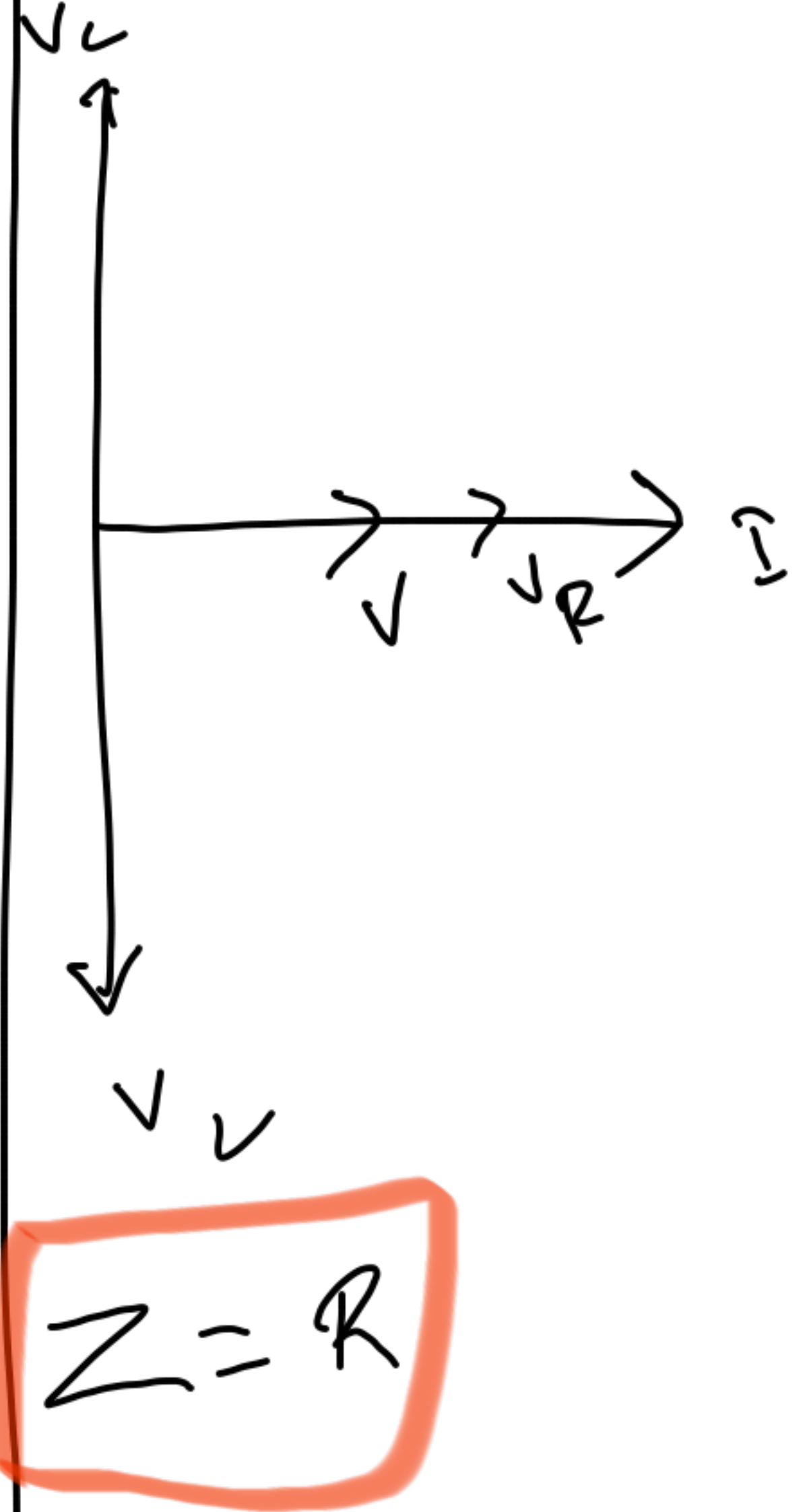
$$\phi = \tan^{-1} \left(\frac{X_L - X_C}{R} \right)$$



$X_L < X_C$

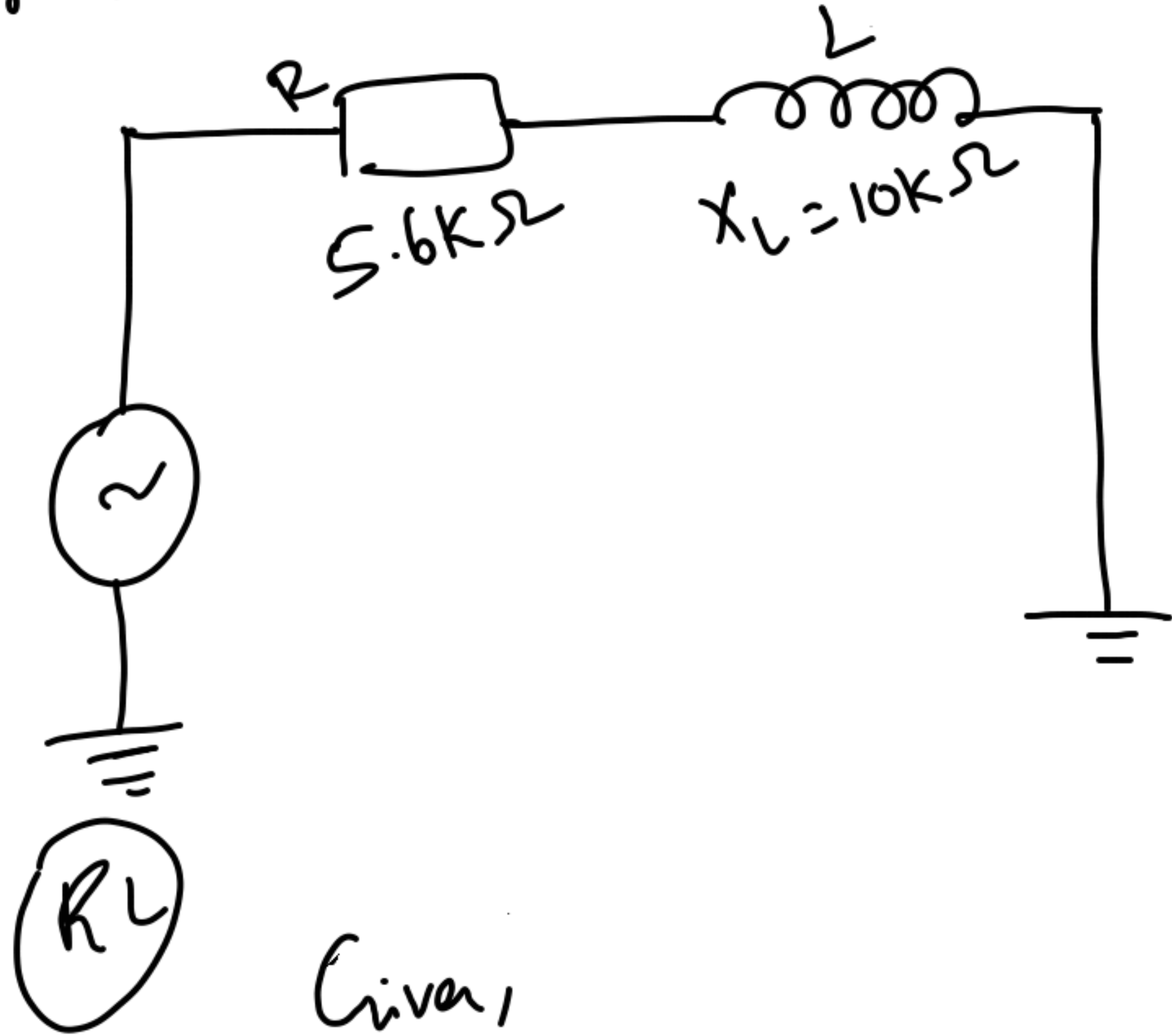


$X_L = X_C$



$$Z = R$$

1) Determine the impedance and phase angle for the circuit shown below



Given,

$$R = 5.6 \text{ k}\Omega$$

$$X_L = 10 \text{ k}\Omega$$

$$Z = \sqrt{R^2 + X_L^2}$$

$$Z = \sqrt{(5.6 \times 10^3)^2 + (10 \times 10^3)^2}$$

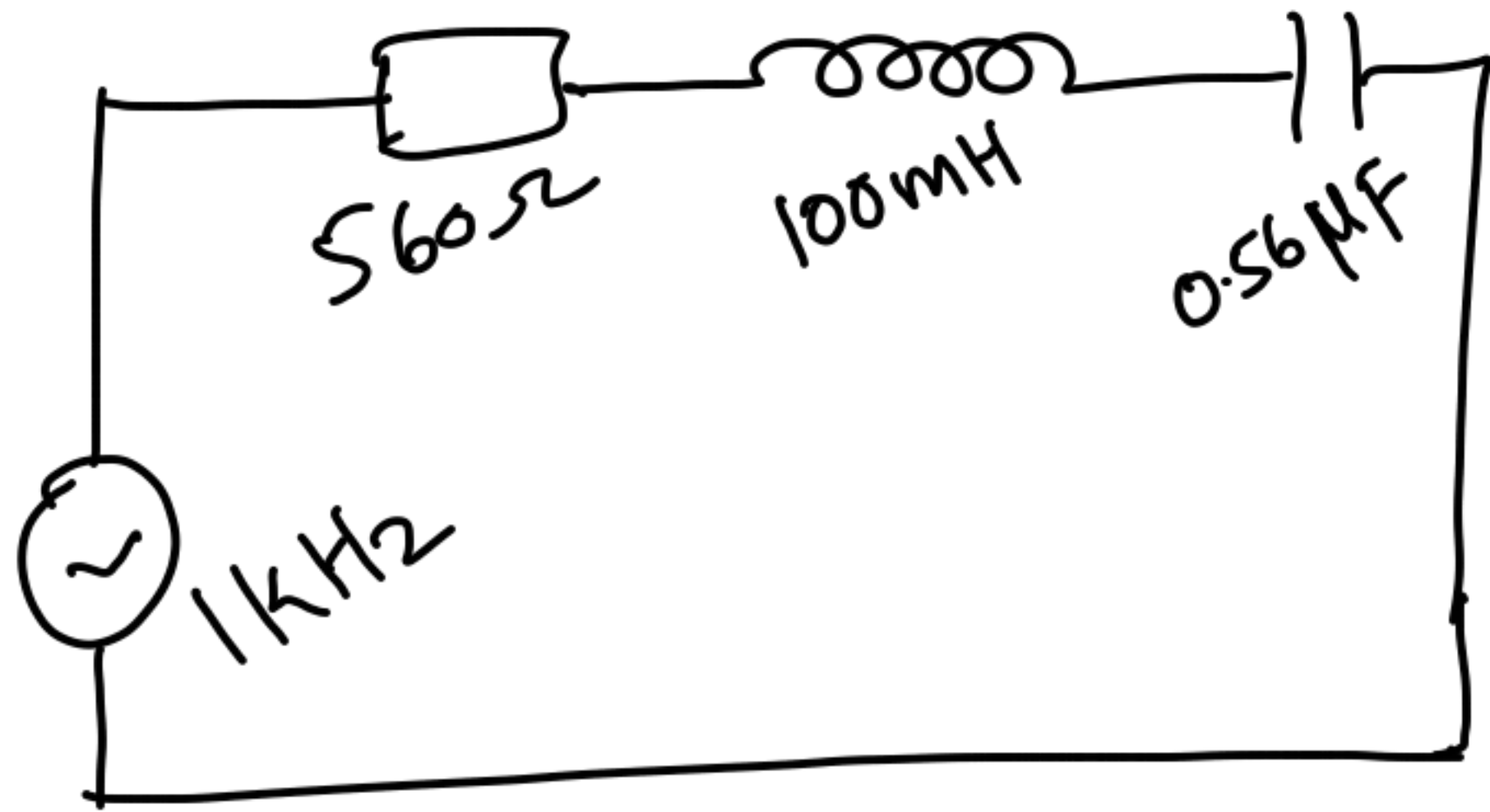
$$Z = 11.46 \text{ k}\Omega$$

$$\phi = \tan^{-1}\left(\frac{X_L}{R}\right)$$

$$\phi = \tan^{-1}\left(\frac{10 \times 10^3}{5.6 \times 10^3}\right)$$

$$\phi = 60.75^\circ$$

2) Calculate the total impedance and phase angle for the circuit shown below.



Soln

$R = 560 \Omega$	$f = 1 \text{ kHz}$
$L = 100 \text{ mH}$	
$C = 0.56 \mu\text{F}$	

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$X_L = 2\pi fL$$

$$= 2\pi \times 1 \times 10^3 \times 100 \times 10^{-3}$$

$$X_L = 628.32 \Omega$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_C = \frac{1}{2\pi \times 1 \times 10^3 \times 0.56 \times 10^{-6}}$$

$$X_C = 284.2 \Omega$$

$$Z = \sqrt{560^2 + [628.32 - 284.2]^2}$$

$$Z = 657.3 \Omega$$

$$\phi = \tan^{-1} \left(\frac{X_L - X_C}{R} \right)$$

$$= \tan^{-1} \left(\frac{628.32 - 284.2}{657.3} \right)$$

$$\phi = 31.6^\circ$$

3) An inductance of 318.3 mH is connected to a Resistor of 200Ω in series. The circuit is supplied with a voltage of 240 V , 50 Hz . Calculate

a) Inductive Reactance

b) Impedance

c) Current in the circuit

d) Potential difference across each Component

e) Phase angle

f) Phasor diagram

g) Impedance plot

h) verify if the Voltage across Component Sum up to total voltage

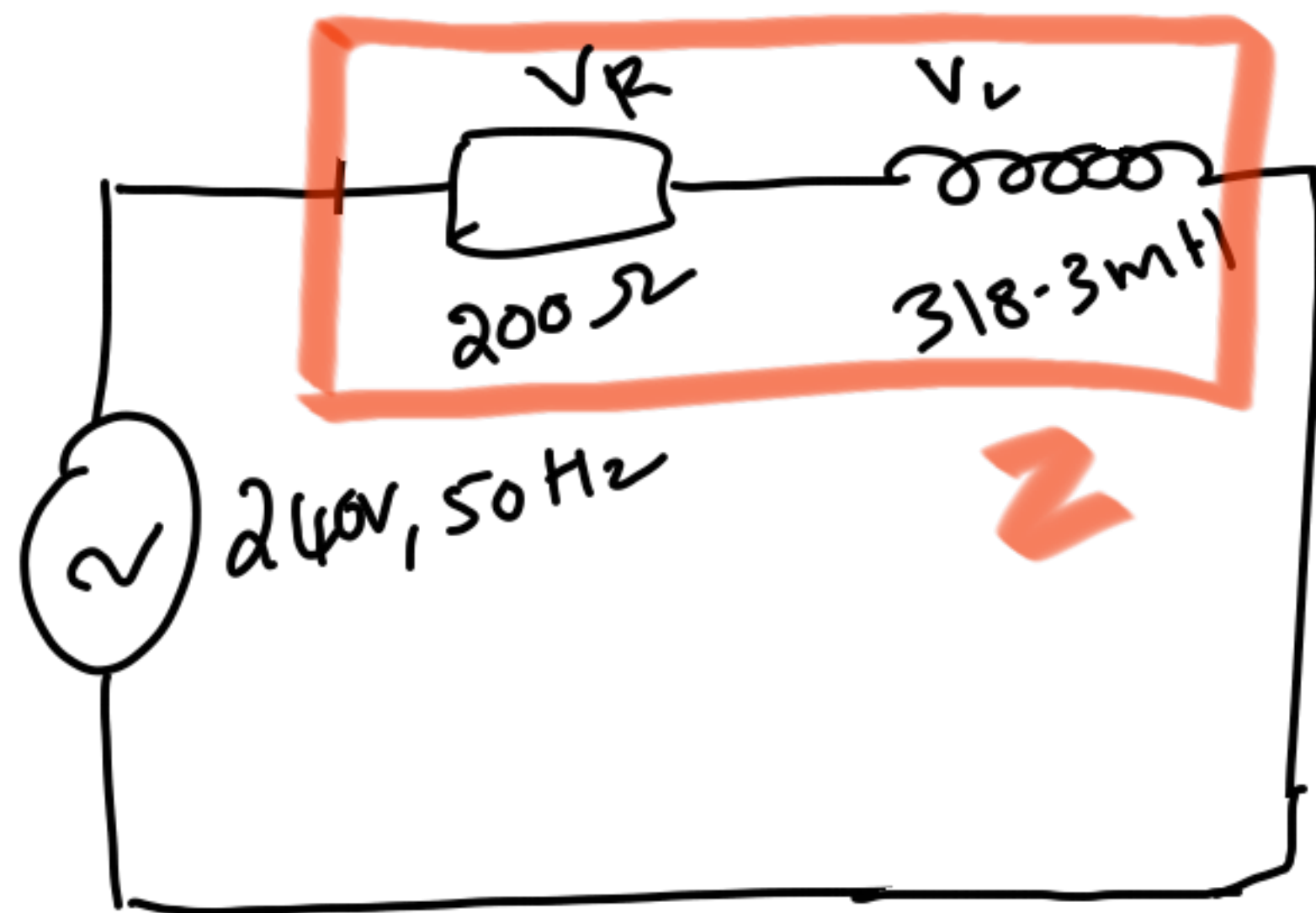
Soln.

Given, $L = 318.3 \text{ mH}$

$$R = 200 \Omega.$$

$$V = 240 \text{ V}$$

$$f = 50 \text{ Hz}.$$



a) Inductive Reactance

$$X_L = 2\pi fL$$

$$X_L = 2\pi \times 50 \times 318.3 \times 10^{-3}$$

$$X_L = 100 \Omega.$$

b) Impedance.

$$Z = \sqrt{R^2 + X_L^2}$$

$$Z = \sqrt{(200)^2 + (100)^2}$$

$$Z = 223.6 \Omega$$

c) Current in the circuit.

$$I = \frac{V}{Z}$$

$$I = \frac{240}{223.6} = 1.07 \text{ A}$$

d) Potential drop across each component.

Across Resistor,

$$V_R = IR$$
$$= 1.07 \times 200$$

$$V_R = 214 \text{ V}$$

Across Inductor.

$$V_L = I \cdot X_L$$

$$= 1.07 \times 100$$

$$V_L = 107 \text{ V}$$

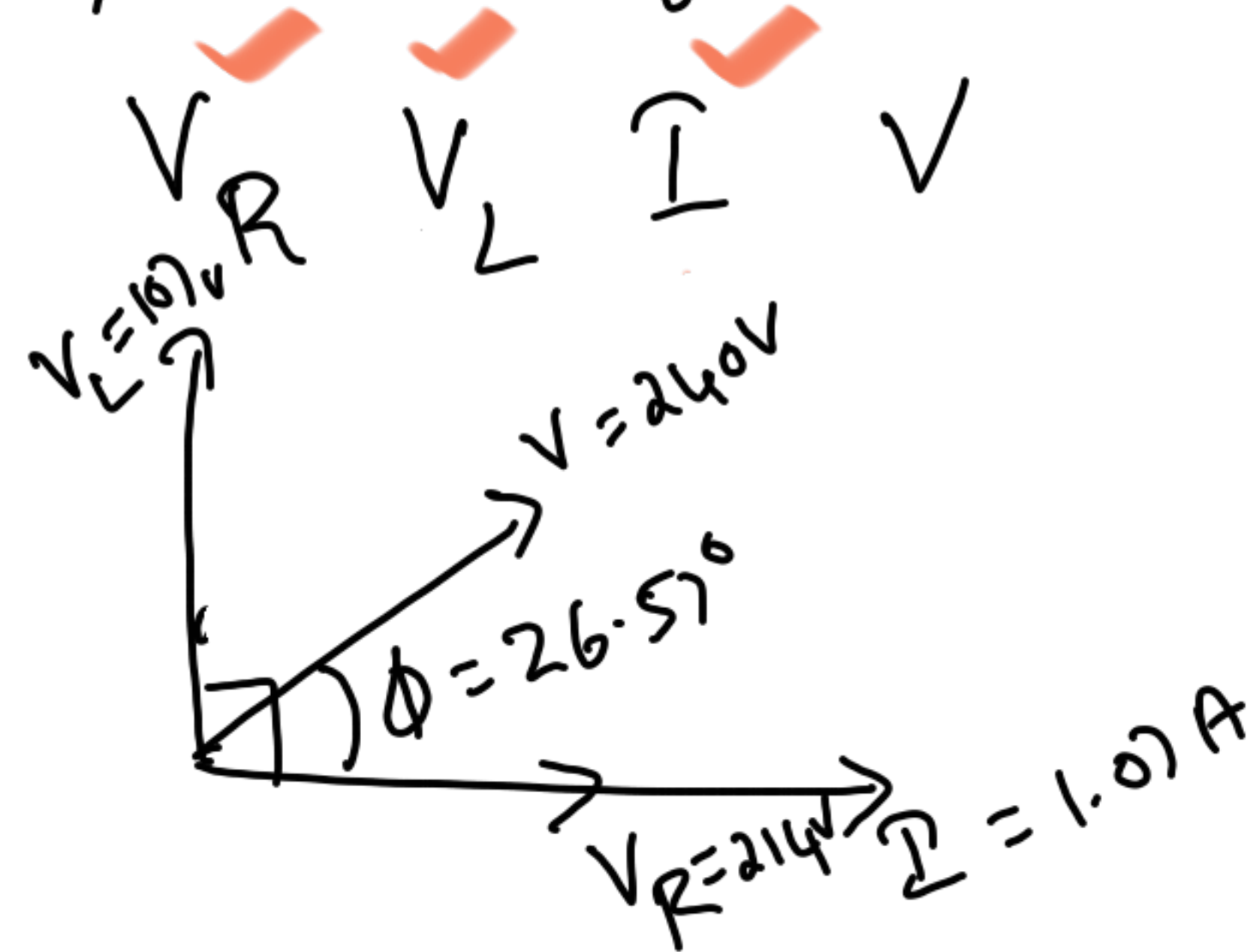
e) phase angle

$$\phi = \tan^{-1} \left(\frac{X_L}{R} \right)$$

$$\phi = \tan^{-1} \left(\frac{100}{200} \right)$$

$$\phi = 26.57^\circ (\text{lagging})$$

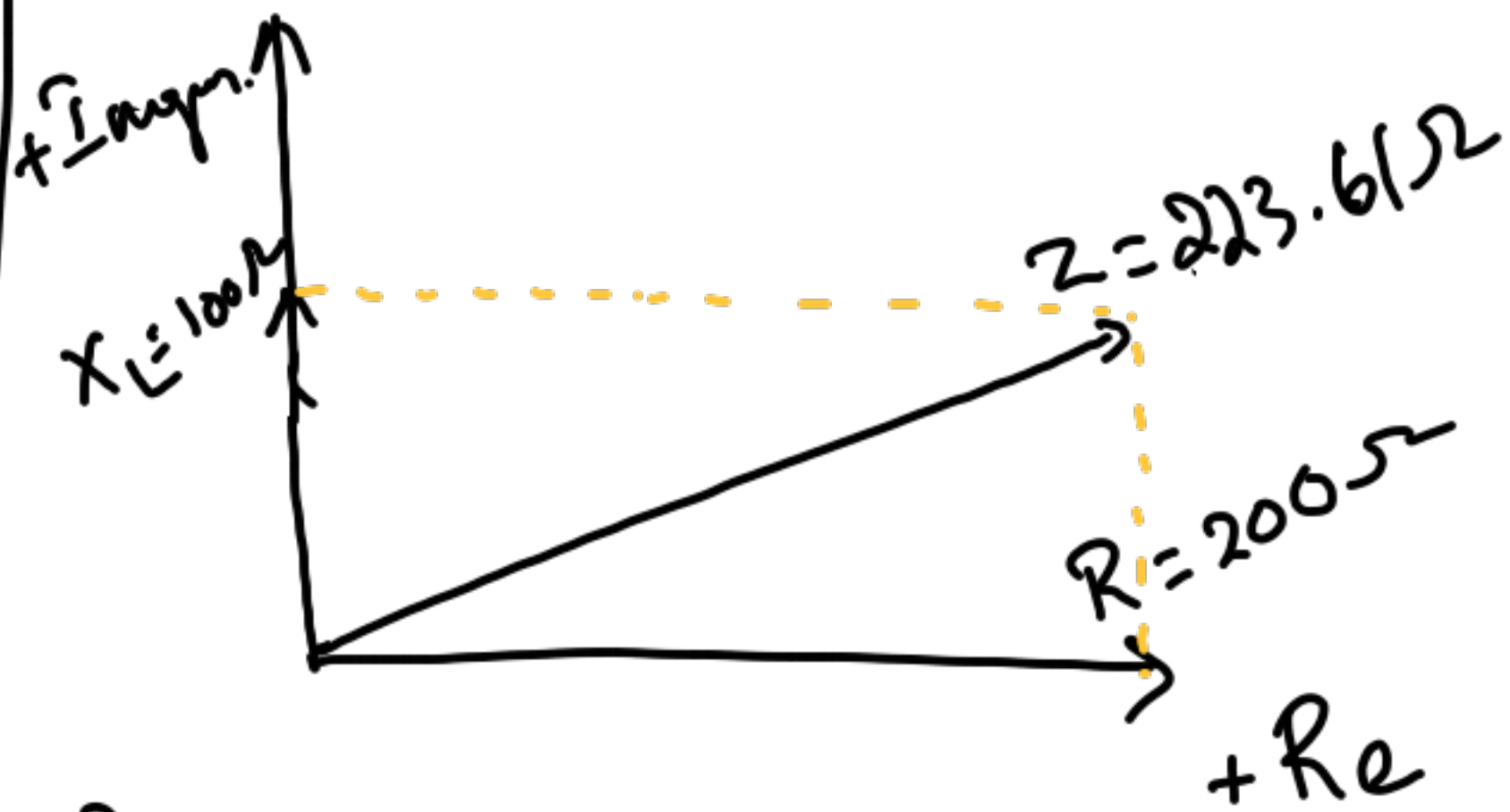
f) Phasor diagrams



g) Impedance plot

$$Z = R + jX_L$$

$$Z = 200 + j100$$



h) Verify if the Voltage Sum up to the total voltage.

$$V = 240, \quad V_R = 214V, \quad V_L = 107V$$

$$V = \sqrt{V_R^2 + V_L^2}$$

$$V = \sqrt{214^2 + 107^2}$$

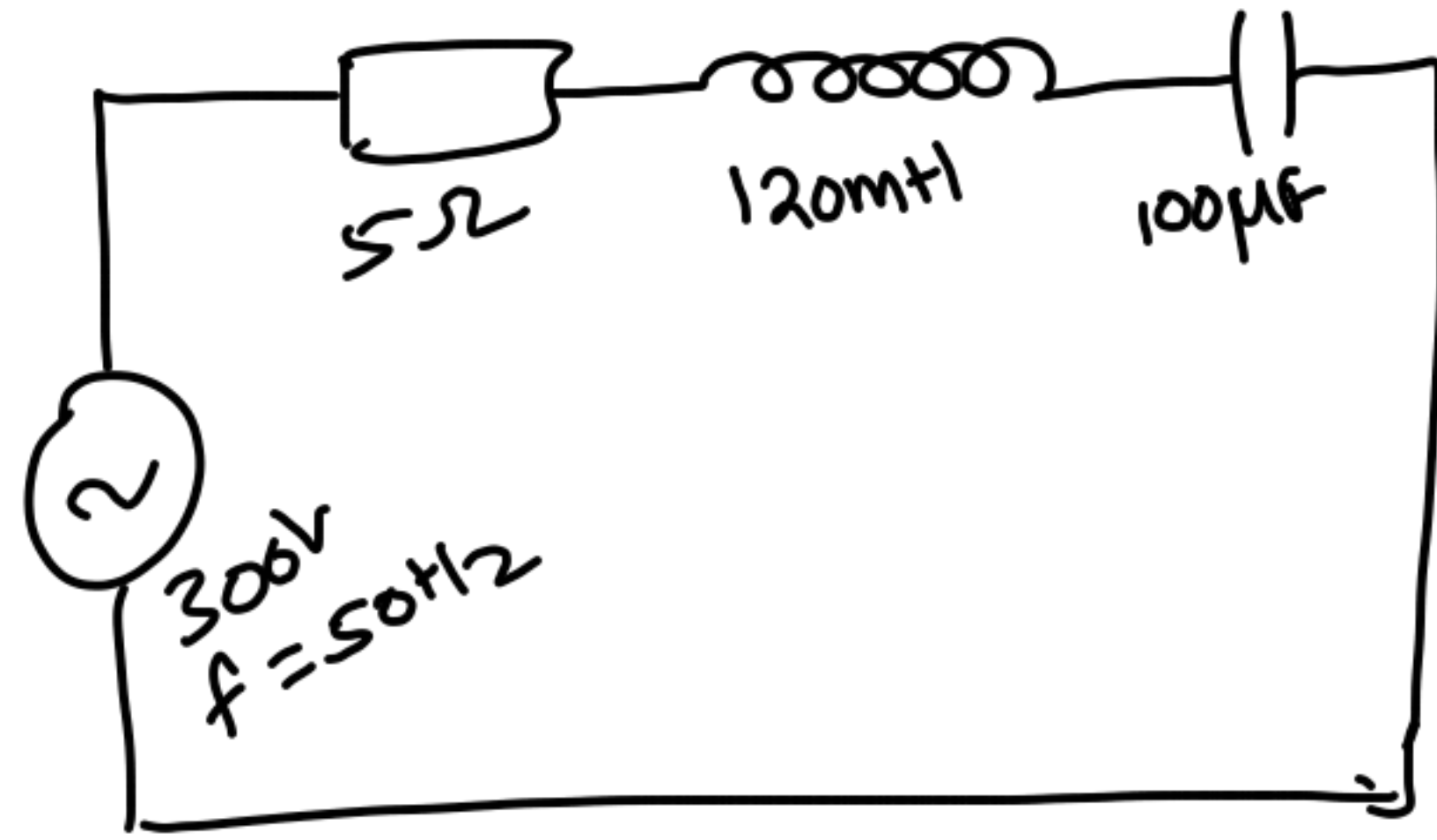
$$V = 240V$$

4) A series RLC circuit has $R=5\Omega$ Sdn.
 $L=120\text{mH}$ and $C=100\mu\text{F}$ connected to
a 300V , 50Hz supply. Calculate

- Reactance
- Impedance
- Current across the circuit
- Voltage across each component
- phase difference
- phasor diagram
- Impedance plot
- Verify if voltage across each component
Sum up to total voltage

$$R=5\Omega, L=120\text{mH}$$

$$C=100\mu\text{F}, V=300\text{V}, f=50\text{Hz}$$



a) Reactance.

$$\begin{aligned} X_L &= 2\pi fL \\ &= 2\pi \times 50 \times 120 \times 10^{-3} \end{aligned}$$

$$X_L = 37.7\Omega$$

$$X_C = \frac{1}{2\pi fC}$$

$$X_C = \frac{1}{2\pi \times 50 \times 100 \times 10^{-6}}$$

$$X_C = 31.83 \Omega$$

b) Impedance

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

$$Z = \sqrt{5^2 + (37.7 - 31.83)^2}$$

$$Z = 7.71 \Omega$$

c) Current.

$$I = \frac{V}{Z} = \frac{300}{7.71}$$

$$I = 38.9 A$$

d) Voltage across each component.

Resistor

$$V_R = I \cdot R = 38.9 \times 5 = 194.5 V$$

Inductor.

$$V_L = I \cdot X_L = 38.9 \times 37.7 = 1466.9 V$$

Capacitor.

$$V_C = I \cdot X_C = 38.9 \times 31.83 = 1238.5 V$$

e) Phase angle

$$\phi = \tan^{-1} \left(\frac{X_L - X_C}{R} \right)$$

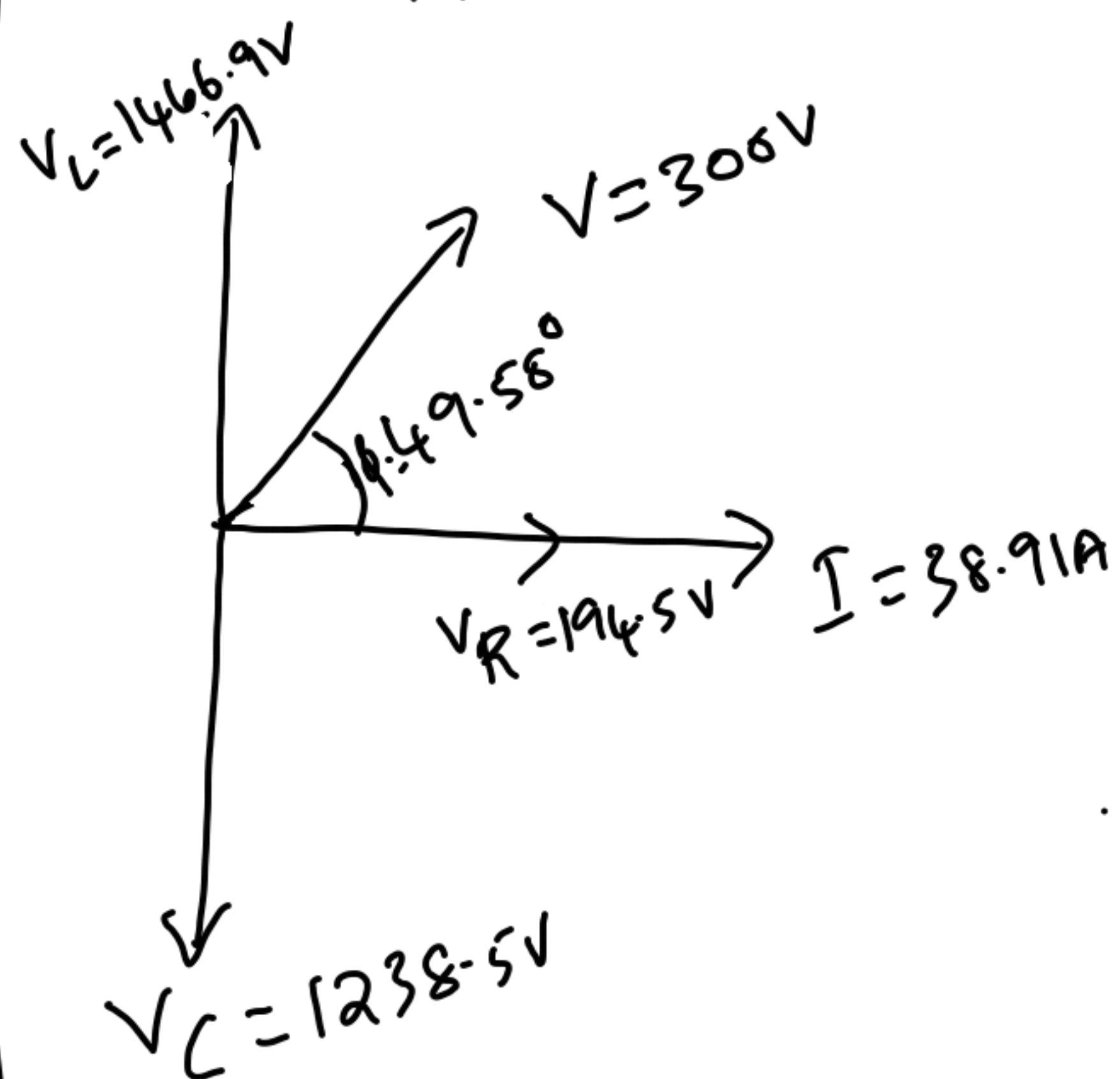
$$\phi = \tan^{-1} \left(\frac{37.7 - 31.83}{5} \right)$$

$$\phi = 49.58^\circ$$

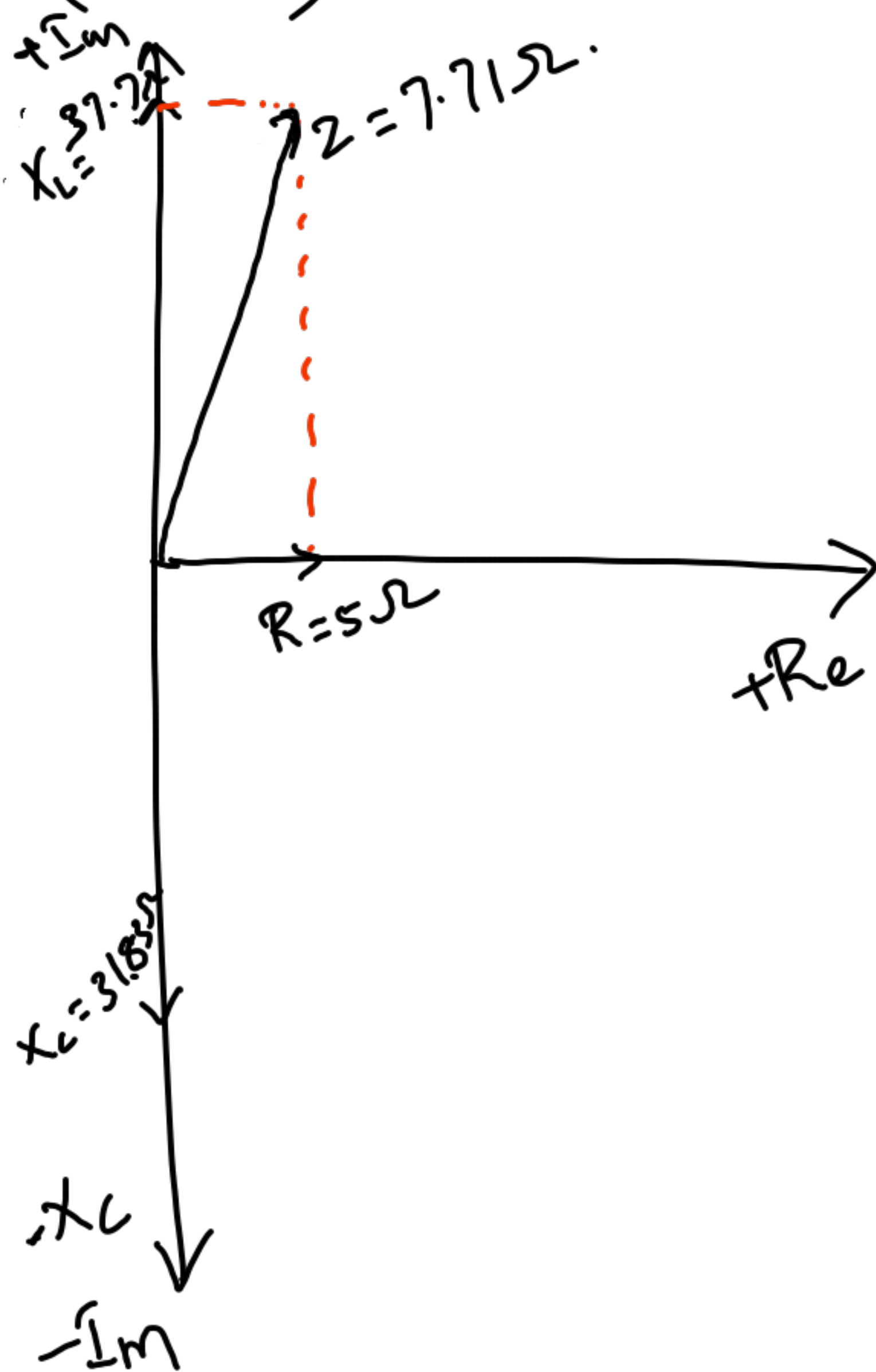
f) Phasor diagram

$$X_L > X_C$$

V, I, V_R, V_L, V_C



g) Impedance plot
($X_L > X_C$)



h) Verify the Voltage

$$V = \sqrt{V_R^2 + (V_L - V_C)^2}$$

$$V = \sqrt{(194.5)^2 + (1466.98 - 1238.5)^2}$$

$$V \approx 300V$$

Resonance

$$\text{At, } X_L = X_C$$

$$2\pi fL = \frac{1}{2\pi fC}$$

$$f^2 = \frac{1}{(2\pi)^2 LC}$$

Taking square root on both the side.

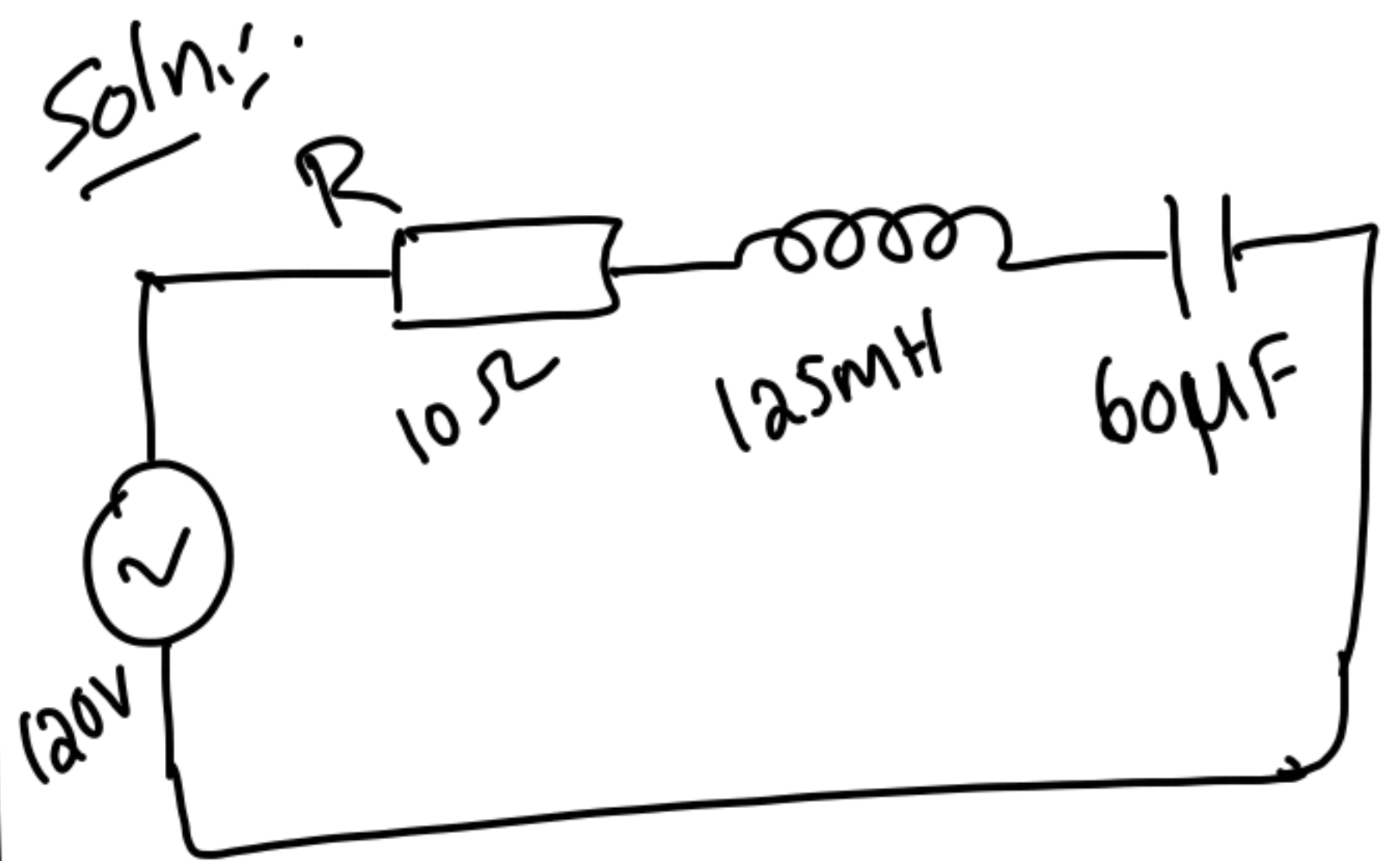
$$f = \sqrt{\frac{1}{(2\pi)^2 LC}}$$

$$f = \frac{1}{\sqrt{(2\pi)^2 LC}}$$

$$f = \frac{1}{2\pi\sqrt{LC}}$$

$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

5) A coil having a resistance of 10Ω and inductance of 125mH is connected in series with a $60\mu\text{F}$ capacitor across a voltage source of 120V . At what frequency does resonance occurs? Calculate the current flowing at Resonant frequency.



$$f_r = \frac{1}{2\pi\sqrt{LC}}$$

$$= \frac{1}{2\pi\sqrt{125 \times 10^{-3} \times 60 \times 10^{-6}}}$$

$$f_r = 58.09\text{Hz}$$

$$I = \frac{V}{Z}$$

At Resonance $X_L = X_C$

$$Z = R$$

$$\begin{aligned} I &= \frac{V}{R} \\ &= \frac{120}{10} \end{aligned}$$

$$I = 12A$$

..